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RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

FREE-SPINNING-TUNNEL TESTS OF A $\frac{1}{20}$-SCALE MODEL OF THE MCDONNELL XF3H-1 AIRPLANE

TED NO. NACA DE 343

By Theodore Berman

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NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

WASHINGTON

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SUMMARY

An investigation was conducted in the Langley 20-foot free-spinning tunnel with a $\frac{1}{20}$-scale model to determine the spin and recovery characteristics of the McDonnell XF3H-1 airplane. The effects of control settings and movements on the erect and inverted spin and recovery characteristics of the model were determined. The effects of extending slats, extending dive brakes, and varying the horizontal tail incidence were also investigated. The investigation included the determination of the minimum-size spin-recovery parachute required for emergency recovery, and estimation of the forces required to move the controls for satisfactory recovery.

The results of the investigation indicated that the spin-recovery characteristics of the airplane will be satisfactory when recovery is attempted by simultaneous movement of the rudder to against the spin and the ailerons to with the spin but may not be satisfactory when attempted by rudder reversal alone. Extension of the wing slats, extension of the dive brakes, or varying the incidence of the horizontal tail will have no appreciable effect on the spin or recovery characteristics of the airplane. The results indicated that a 16.7-foot-diameter tail parachute with a towline 25.0 feet long and a drag coefficient of 0.85 will insure recovery from spins in an emergency by parachute action alone. Estimations indicated that the forces required to move the controls for satisfactory recovery will be within the pilot's capabilities.

INTRODUCTION

In accordance with the request of the Bureau of Aeronautics, Department of the Navy, tests were performed in the Langley 20-foot free-spinning tunnel to determine the spin and recovery characteristics of a $\frac{1}{20}$-scale model of the McDonnell XF3H-1 airplane. This airplane is a single-place midwing jet-propelled fighter with sweptback wing and tail surfaces.

The erect and inverted spin and recovery characteristics of the model were determined for the design gross weight loading and a few tests were made with the mass distribution along the fuselage increased. Tests were made to determine the effects of extending the slats, of extending the dive brakes, and of varying the incidence of the horizontal tail, and also to determine the minimum parachute size for emergency recovery.

SYMBOLS

b	wing span, feet
S	wing area, square feet
c	wing or elevator chord at any station along span
$\bar{c}$	mean aerodynamic chord, feet
$x/\bar{c}$	ratio of distance of center of gravity rearward of leading edge of mean aerodynamic chord to mean aerodynamic chord
$z/\bar{c}$	ratio of distance between center of gravity and fuselage reference line to mean aerodynamic chord, positive when center of gravity is below fuselage reference line
m	mass of airplane, slugs
I_X, I_Y, I_Z	moments of inertia about X, Y, and Z body axes, respectively, slug-feet^2
$\frac{I_X - I_Y}{mb^2}$	inertia yawing-moment parameter
$\frac{I_Y - I_Z}{mb^2}$	inertia rolling-moment parameter

$\frac{I_Z - I_X}{mb^2}$	inertia pitching-moment parameter
ρ	air density, slugs per cubic foot
μ	relative density of airplane $(m/\rho Sb)$
α	angle between fuselage reference line and vertical (approx. equal to absolute value of angle of attack at plane of symmetry), degrees
ϕ	angle between span axis and horizontal, degrees
V	full-scale true rate of descent, feet per second
Ω	full-scale angular velocity about spin axis, revolutions per second
σ	helix angle, angle between flight path and vertical, degrees (For the tests of this model, the average absolute value of the helix angle was approx. 2°.)
β	approximate angle of sideslip at center of gravity, degrees (Sideslip is inward when inner wing is down by an amount greater than the helix angle.)

APPARATUS AND METHODS

Model

The $\frac{1}{20}$-scale model of the McDonnell XF3H-1 airplane was furnished by the Bureau of Aeronautics, Department of the Navy, and was prepared for testing by the Langley Laboratory of the National Advisory Committee for Aeronautics. A three-view drawing of the model as tested is shown in figure 1. A photograph showing the model in the normal flying configuration which includes stall-control vanes and wing-tip skids is shown in figure 2 and photographs of the model with slats extended and with dive brakes extended are shown in figures 3 and 4, respectively. Dimensional characteristics of the airplane are presented in table I. Tail-damping power factor was computed by the method described in reference 1.

The model was ballasted to obtain dynamic similarity to the airplane at an altitude of 19,000 feet (ρ = 0.001311 slug/cu ft). A remote-control mechanism was installed in the model to actuate the controls for the recovery attempts and to open the parachute for the parachute tests. Sufficient moments were exerted on the controls for the recovery attempts to reverse them fully and rapidly.

Wind Tunnel and Testing Technique

The tests were performed in the Langley 20-foot free-spinning tunnel, the operation of which is generally similar to that described in reference 2 for the Langley 15-foot free-spinning tunnel, except that the models are launched by hand with spinning rotation rather than launched by spindle into the vertically rising air stream. After a number of turns in the established spin, recovery is attempted by moving one or more controls. After recovery the model dives into a safety net. A photograph of the model during a spin is shown in figure 5.

The spin data presented were obtained and converted to corresponding full-scale values by methods described in reference 2. The turns for recovery were measured from the time the controls were moved, or the parachute was opened, to the time the spin rotation ceased and the model dived into the net. For the spins which had a rate of descent in excess of that which can readily be attained in the tunnel, the rate of descent was recorded as greater than the velocity at the time the model hit the safety net, for example, >300. For these tests, the recovery was attempted before the model reached its final steeper attitude and while the model was still descending in the tunnel. Such results are conservative; that is, recoveries will not be as fast as when the model is in the final steeper attitude. For recovery attempts in which the model struck the safety net while it was still in a spin, the recovery was recorded as greater than the number of turns from the time the controls were moved to the time the model struck the net, as >3. A >3-turn recovery does not necessarily indicate an improvement over a >7-turn recovery. For recovery attempts in which the model did not recover, the recovery result was recorded as ∞. When the model recovered without control movement, with the controls with the spin, the results were recorded as "no spin."

Spin-tunnel tests are usually made to determine the spin and recovery characteristics of the model at the normal spinning control configuration (elevator full up, ailerons neutral, and rudder full with the spin) and at various other aileron-elevator control combinations including zero and maximum deflections. Recovery is generally attempted by rapid full rudder reversal. During this investigation, recoveries were sometimes attempted by simultaneous movement of the rudder and ailerons. Tests are also performed to evaluate the possible adverse effects on recovery of small deviations from the normal control configuration for spinning. For these tests, the ailerons are set at one-third of the full deflection in the direction conducive to slower recoveries and the elevator is set at two-thirds of its full-up deflection or full up, whichever is conducive to slower recovery. Recovery is attempted by rapidly reversing the rudder from full with the spin to two-thirds against the spin or by simultaneous rudder and elevator movement or, as for the present investigation, simultaneous rudder reversal to two-thirds against the spin and aileron movement to with the spin. This control configuration is referred to as the "criterion spin." Recovery characteristics of the model are considered satisfactory if recovery from this criterion spin requires $2\frac{1}{4}$ turns or less. This value has been selected on the basis of full-scale airplane spin-recovery data that are available for comparison with corresponding model test results.

The testing technique for determining the optimum size of, and the towline length for, spin-recovery parachutes is described in detail in reference 3. For the tail-parachute tests the towline was attached to the model at the top of the fuselage rearward of the vertical tail and the parachute was packed under the horizontal tail on the right side of the fuselage for right spins. Wing-tip parachutes were attached to the outer wing tip with the towline length adjusted so that the parachute would miss the horizontal tail. In every case the folded parachute was placed on the fuselage or wing in such a position that it did not seriously influence the established spin before the parachute was opened. Full-scale parachute installations should be provided with positive means of ejection. For the current tests, the rudder was held with the spin during recovery so that recovery was due entirely to the effect of opening the parachute. Nylon flat-type parachutes having a drag coefficient of approximately 0.85 (based on the canopy area measured with the parachute spread out flat) were used for the spin-recovery parachute tests.

PRECISION

The model test results presented are believed to be true values given by the model within the following limits:

α, degrees	±1
ϕ, degrees	±1
V, percent	±5
Ω, percent	±2

Turns for recovery:

From motion-picture records	±1/4
From visual observation	±1/2

The preceding limits may have been exceeded for some of the spins in which it was difficult to control the model in the tunnel because of the high rate of descent or because of the wandering or oscillatory nature of the spin.

Comparison between model and full-scale results (reference 4) indicates that model tests satisfactorily predicted full-scale recovery characteristics approximately 90 percent of the time and for the remaining 10 percent of the time the model results were of value in predicting some of the details of the full-scale spins. The airplanes generally spun at an angle of attack closer to 45° than did the model and at a higher altitude loss per revolution than the model although the higher rate of descent was found to be associated with the smaller angle of attack, whether of airplane or model.

Because it is impracticable to ballast the model exactly and because of the inadvertent damage to the model during tests, the measured weight and mass distribution of the XF3H-1 model varied from the true scaled-down values within the following limits:

Weight, percent	1 low to 0
Center-of-gravity location, percent $\bar{c}$	0
Moments of inertia:	
I_X, percent	2 low to 3 high
I_Y, percent	2 low
I_Z, percent	0 to 1 high

The accuracy of measuring weight and mass distribution is believed to be within the following limits:

Weight, percent	±1
Center-of-gravity location, percent $\bar{c}$	±1
Moments of inertia, percent	±5

Controls were set with an accuracy of ±1°.

TEST CONDITIONS

The mass characteristics and inertia parameters for loadings possible on the airplane and for the loading of the model during tests are shown in table II and plotted in figure 6. As discussed in reference 5, figure 6 has been used as an aid in predicting the relative effectiveness of the controls on the recovery characteristics of models through a range of loadings. The XF3H-1 loadings, however, are beyond the range of loadings in reference 5 and therefore there is some doubt that the control effectiveness of the current design can be completely predicted by the use of reference 5.

The maximum control deflections used in the tests were:

Rudder, degrees	30 right, 30 left
Elevator, degrees	30 up, 15 down
Ailerons, degrees	30 up, 30 down

Intermediate control deflections used were:

Rudder, two-thirds deflected, degrees	20
Ailerons, one-third deflected, degrees	10 up, 10 down

This design includes a spoiler on the upper surface of both wings so linked that the spoiler on the side of the up aileron moves up to full deflection when the ailerons are one-half deflected. The model spoiler used was always in the full-up position whether the ailerons were fully or partly deflected.

Tests were also performed with the slats fully extended and the dive brakes fully extended. The horizontal tail, which was normally at an incidence of 0°, was set at the maximum incidences of 5.5° and -15° for a few tests.

RESULTS AND DISCUSSION

The results of the spin tests are presented in charts 1 to 3 and in table III. The model data are presented in terms of the full-scale values for the airplane at a test altitude of 19,000 feet. Right and left spins were quite similar so that data for right spins only are arbitrarily presented in the charts.

Design Gross Weight Loading

Erect spins.- The results of erect-spin tests indicated that, in general, three conditions were possible. The first was that the model motion was so oscillatory that the model would not spin. The second condition was a relatively steep, oscillatory spin from which recovery by rudder reversal was satisfactory, and the third condition was a flat spin that was very oscillatory in roll, yaw, and pitch and from which recovery could not be obtained by rudder reversal alone but from which recovery by simultaneous movement of the rudder to against the spin and the ailerons to with the spin (stick right in a right spin) was satisfactory.

The results of erect-spin tests of the model in the design gross weight loading (loading point 1 in table II and fig. 6) are shown in chart 1.

When the ailerons were with the spin, only the steep type of spin was obtained. When the ailerons were neutral and the elevator was neutral or down, the steep spin only was obtained. When, however, the elevator was full up and the ailerons were neutral or for all elevator settings with the ailerons against the spin all three types of conditions were obtainable. In some cases, the satisfactory and unsatisfactory recoveries were obtained from separate spins but in other cases they were obtained from different phases of the same spin.

The "no spins" obtained were a result of oscillations of the type described in reference 6. The data presented in reference 6 for straight-wing designs indicate that a model with an inertia yawing-moment parameter and side-area-moment factor similar to the XF3H-1 should not spin steadily and the current tests agree with this indication. Previous spin-tunnel and full-scale experience indicated that a design in the range of inertia yawing-moment parameter and side-area-moment factor of the XF3H-1 would have no difficulty in recovering by rudder reversal alone regardless of the value of tail-damping power factor because the violent oscillations should result in the model entering attitudes in which the rudder would be effective for recovery. The XF3H-1, however, did not recover satisfactorily by rudder reversal alone and a very brief investigation was made in an attempt to determine the causes of the unsatisfactory recoveries. The results of the tests, although not presented numerically, showed that when the sharp nose of the fuselage was cut off, leaving a blunt edge, the model would not spin. This result and results obtained in other current spin-tunnel investigations indicate that a long-pointed fuselage nose section may lead to flat spins and critical recovery characteristics. There is some question as to whether the full-scale airplane will encounter this critical condition but, if it does, recovery should be satisfactory if attempted by reversal of the rudder and movement of the ailerons to with the spin.

Brief tests indicated that the spoilers, wing-tip skids, and wing stall-control vanes which are part of the basic design had little effect on the model spin and recovery characteristics when they were removed. The results of these tests are not presented in chart form.

Inverted spins.- The results of the inverted-spin tests of the model in the design gross-weight loading are presented in chart 2. The order used for presenting the data for inverted spins is different from that used for erect spins. For inverted spins, controls crossed for the established spin (right rudder pedal forward and stick to the pilot's left for a spin to the pilot's right) is presented to the right of the chart and stick back is presented at the bottom. When the controls are crossed in the established spin, the ailerons aid the rolling motion; when the controls are together, the ailerons oppose the rolling motion. The angle of wing tilt ϕ in the chart is given as up or down relative to the ground.

The model spun inverted at all control configurations for which spins were attempted and recoveries from all spins were rapid by reversal of the rudder alone. The rapid recoveries are attributed to the fact that in the inverted attitude the entire rudder is unshielded and thus was effective in causing recovery.

Slats extended, dive brakes extended, and incidence of the horizontal tail varied.- The results of tests with the slats extended, dive brakes extended, and the horizontal tail set at incidences of 5.5° and -15° were very similar to those for the normal flying condition and numerical data are therefore not presented.

Variation of Loading

Spin-tunnel experience has indicated that variation of the loading through the range possible for the XF3H-1 $\left(\frac{I_X - I_Y}{mb^2} = -498 \times 10^{-4}\right.$ to $\left.\frac{I_X - I_Y}{mb^2} = -570 \times 10^{-4}\right)$ should not greatly affect the spin and recovery characteristics. Brief tests, presented in chart 3, indicated that increasing the inertia yawing-moment parameter negatively to -642×10^{-4} caused very little change in the spin and recovery characteristics of the model. Based on the data in reference 6 and on spin-tunnel experience it had been expected that the model motion would become more oscillatory and that the model would be more likely not to spin for all control settings. The reason that the model spin and recovery characteristics were not as expected is felt to be connected with the nose shape and length as previously discussed.

Spin-Recovery Parachutes

The results of spin-recovery parachute tests are presented in table III. A tail parachute 16.7 feet in diameter with a towline 25.0 feet long was indicated as necessary for satisfactory recovery of the airplane by parachute action alone.

Tests made with parachutes attached to the outer wing tip of the airplane indicated that wing-tip parachutes would not always open properly or stay open properly, probably because of the wake of the wing. The parachutes, when they did open properly, only stayed open a short time and then collapsed and fell onto the wing and as a result no satisfactory wing-tip parachute could be found.

The model parachutes as tested had values of drag coefficient of approximately 0.85. If a parachute with a different drag coefficient is used on the airplane, a corresponding adjustment will be required in parachute size.

Pilot Escape

Specific tests were not made to determine the safety with which the pilot could escape, if necessary, in a spin, but based on the data in reference 7 it appears that pilot escape will be hazardous unless some form of ejection seat is used.

Landing Condition

The landing condition was not investigated on this model inasmuch as current Navy specifications require this type of airplane to demonstrate satisfactory recoveries in the landing condition from only one-turn spins. At the end of one turn, the airplane will probably still be in an incipient spin from which recoveries are more readily obtained than from fully developed spins.

An analysis of model tests to determine the effect of landing flaps and landing gear (reference 8) indicates that in the event a spin is entered in the landing condition, the flaps and landing gear should be retracted immediately.

Control Forces

The discussion of the results so far has been based on control effectiveness alone without regard to the forces required to move the controls. As previously mentioned, sufficient force was applied to the controls to move them fully and rapidly. The airplane controls should be moved in a similar manner in order for the model and airplane results to be comparable.

Calculations were made to determine the magnitude of rudder forces required for recovery from the spins obtained with the model and they showed that full reversal of the rudder would require approximately 100 pounds in the flat spin and approximately 300 pounds in the steep spin. Both of these values should be within the capabilities of a pilot.

Aileron forces were not calculated because aileron hinge-moment data were not available but full-scale spin data available indicate that the force required to move ailerons with the spin should not be heavy.

Recommended Recovery Technique

Based on the results obtained with the model, the following recommendations are made as to recovery technique for all loadings, for erect spins: the rudder should be reversed briskly from full with the spin to full against the spin simultaneously with movement of the stick to with the spin laterally; approximately one-half turn later the stick should be moved forward longitudinally. For inverted spins, recovery should be satisfactory by full reversal of the rudder. Care should be exercised to avoid excessive rates of acceleration in the recovery dive.

CONCLUSIONS

Based on the results of spin tests of a $\frac{1}{20}$-scale model of the McDonnell XF3H-1 airplane, the following conclusions regarding the spin and recovery characteristics of the airplane at a spin altitude of 19,000 feet have been drawn:

1. The spin-recovery characteristics of the airplane are satisfactory for all loadings if the following technique is used: brisk rudder reversal simultaneous with movement of the ailerons to with the spin (stick right in a right spin); one-half turn later, the stick should be moved forward longitudinally.

2. Extension of the leading-edge slats, extension of the dive brakes, or varying the incidence of the horizontal tail has no appreciable effect on the spin or recovery characteristics of the airplane.

3. A 16.7-foot-diameter tail parachute with a towline 25.0 feet long and a drag coefficient of 0.85 is satisfactory for emergency recoveries from spins by parachute action alone.

4. The forces required to move the controls for recovery are within the pilot's capabilities.

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TABLE I.- DIMENSIONAL CHARACTERISTICS OF THE MCDONNELL XF3H-1 AIRPLANE

Length over all, feet	59.4
Wing:	
Span, feet	35.3
Area, square feet	415.0
Sweepback at c/4, degrees	45
Incidence, degrees	2
Dihedral, degrees	0
Section (parallel to plane of symmetry):	
Root	NACA 0009-1.16 38/1.14 Modified
Tip	NACA 0007-1.16 38/1.14 Modified
Aspect ratio	3.0
Mean aerodynamic chord, inches	146.4
Leading edge of $\bar{c}$ rearward of leading edge of root chord, inches	104.2
Ailerons:	
Area, square feet (rearward of hinge)	17.4
Span, percent b/2	0.267
Hinge-line location, percent c	0.800
Horizontal tail:	
Total area, square feet	70.0
Span, feet	14.5
Sweepback at c/4, degrees	45
Elevator area rearward of hinge line, square feet	11.5
Distance from normal center of gravity to elevator hinge line at root, feet	25.14
Dihedral, degrees	0
Incidence, degrees	5.5 up, 15 down
Vertical tail:	
Total area, square feet	45.4
Sweepback at c/4, degrees	45
Rudder area rearward of hinge line, square feet	11.3
Distance from normal center of gravity to rudder hinge line at root of rudder, feet	24.1
Unshielded rudder volume coefficient	0
Tail-damping ratio	0.0114
Tail-damping power factor	0
Side-area moment factor	0.68

TABLE II.- MASS CHARACTERISTICS AND INERTIA PARAMETERS FOR LOADING CONDITIONS POSSIBLE ON THE MCDONNELL XF3H-1 AIRPLANE AND FOR THE LOADINGS TESTED ON THE $\frac{1}{20}$- SCALE MODEL

[Model values converted to corresponding full-scale values; moments of inertia are given about center of gravity]

Number (same as fig. 6)	Loading	Weight (lb)	μ (sea level)	μ (19,000 ft)	Center-of-gravity location		Moments of inertia (slug-feet^2)			Mass parameters		
					$x/\bar{c}$	$z/\bar{c}$	I_X	I_Y	I_Z	$\frac{I_X - I_Y}{mb^2}$	$\frac{I_Y - I_Z}{mb^2}$	$\frac{I_Z - I_X}{mb^2}$
Airplane values												
1	Design gross weight	18,366	16.4	29.7	0.286	0.008	13,488	53,625	62,733	-565×10^{-4}	-128×10^{-4}	693×10^{-4}
2	Overload gross weight	20,256	18.1	32.8	.277	.012	15,192	54,244	65,067	-498	-138	636
3	Combat gross weight	18,468	16.5	29.9	.286	.007	13,463	53,698	62,839	-563	-128	691
Model values												
I	Design gross weight	18,134	16.2	29.3	0.286	0.014	13,646	52,550	62,768	-554×10^{-4}	-146×10^{-4}	700×10^{-4}
4	Mass extended along fuselage	18,382	16.4	29.7	.290	.003	13,248	58,948	69,702	-642	-151	793

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TABLE III.- SPIN-RECOVERY PARACHUTE DATA OBTAINED WITH THE

$\frac{1}{20}$-SCALE MODEL OF THE MCDONNELL XF3H-1 AIRPLANE

[Loading point 1 in table II and figure 6; rudder full with the spin; model values converted to corresponding full-scale values; C_D of parachute 0.85; right erect spins]

Parachute diameter (ft)	Towline length (ft)	Ailerons	Elevator	Turns for recovery
Tail parachutes				
13.3	25	Neutral	Full up	∞
15.0	25	1/3 against	Full up	$\frac{1}{2}$, $3\frac{1}{2}$, >3
16.7	25	1/3 against	Full up	1, 1, $1\frac{1}{4}$
16.7	25	Neutral	Full up	$\frac{3}{4}$, 1, 1

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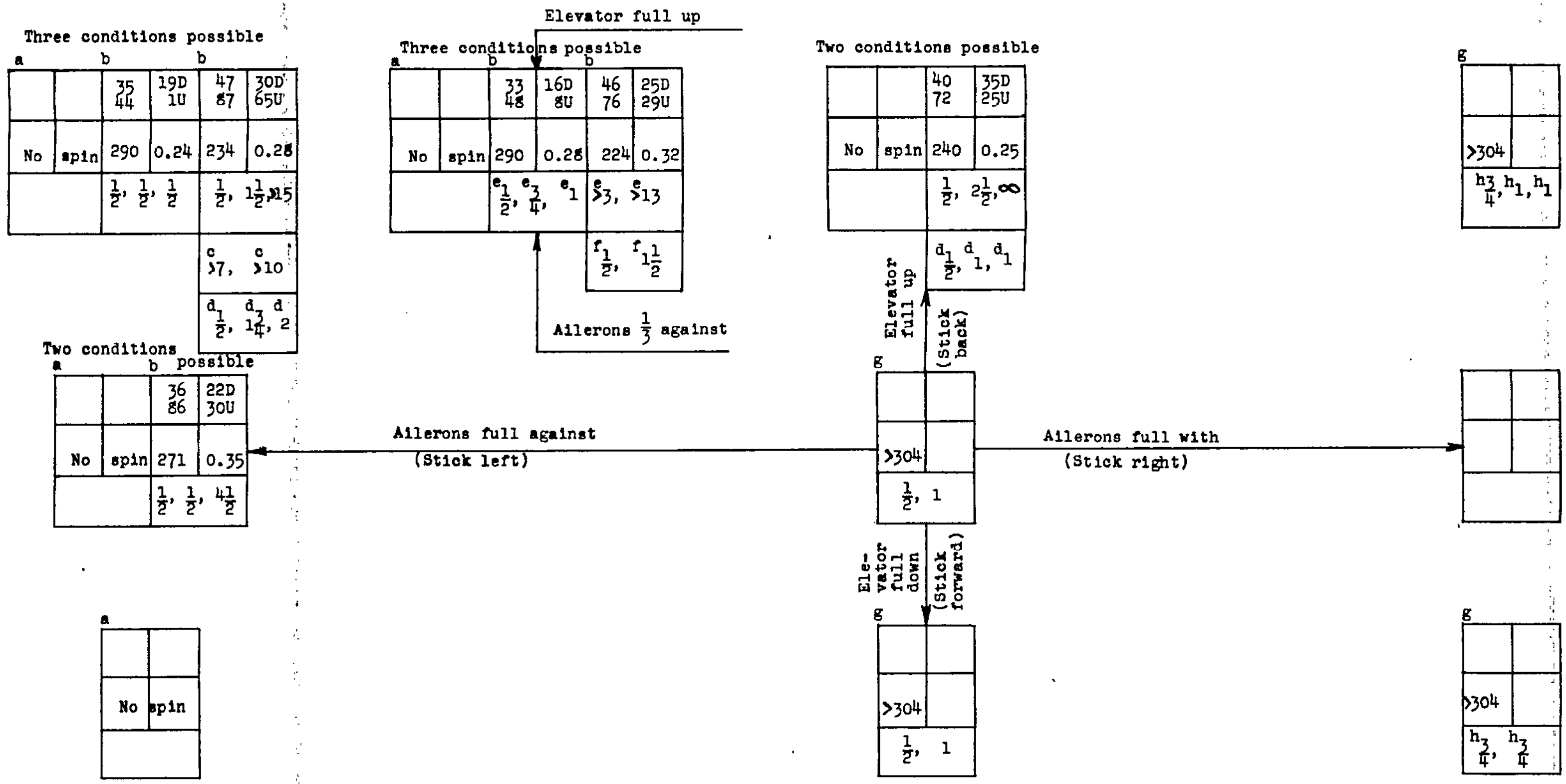
CHART 1.- SPIN AND RECOVERY CHARACTERISTICS OF THE $\frac{1}{20}$-SCALE MODEL OF THE McDONNELL XF3H-1 AIRPLANE IN THE DESIGN GROSS WEIGHT LOADING

[Loading point 1 in table II and figure 6; cockpit closed; landing gear and flaps retracted; recovery by rapid full rudder reversal except as noted (recovery attempted from, and steady-spin data presented for, rudder full-with spins); right erect spins]



[a] After launching, model motion became extremely oscillatory in roll, yaw, and pitch until the model abruptly pitched into a dive and then started to roll left with the ailerons.
[b] Extremely oscillatory spin. Average value or range of values given.
[c] Recovery attempted by movement of the ailerons to full with the spin.
[d] Recovery attempted by simultaneous full movement of the rudder to against the spin and the ailerons to with the spin.
[e] Recovery attempted by reversal of the rudder to $\frac{2}{3}$ against the spin.
[f] Recovery attempted by simultaneous movement of the rudder to $\frac{2}{3}$ against the spin and the ailerons to $\frac{2}{3}$ with the spin.
[g] Recovery attempted before model in final steeper attitude.
[h] Model recovered by going into an inverted dive and then into an aileron roll.

Model values converted to corresponding full-scale values.
U inner wing up
D inner wing down

α (deg)	φ (deg)
V (fps)	Ω (rps)
Turns for recovery	

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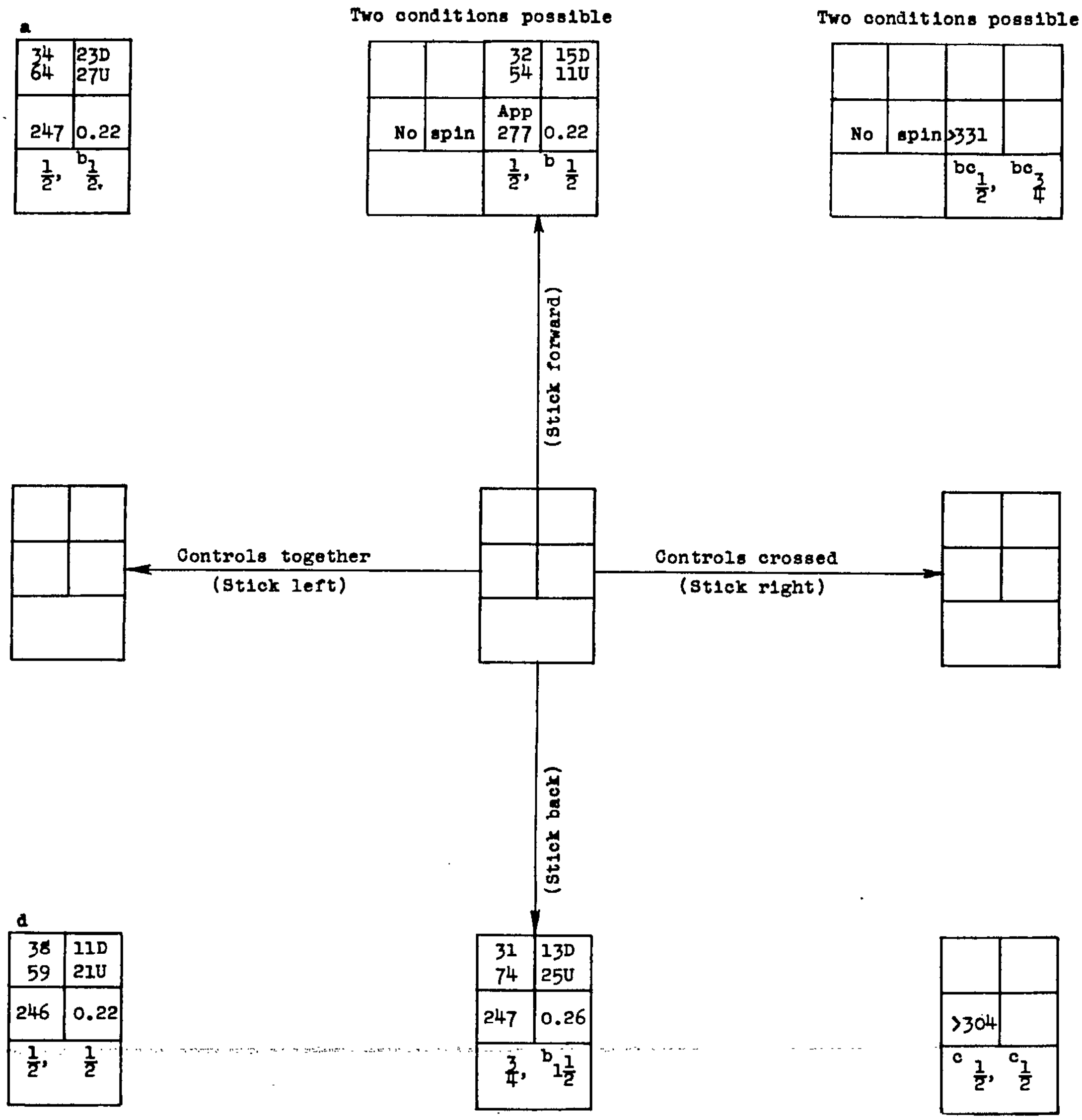
[redacted]

[redacted]

CHART 2.- INVERTED SPIN AND RECOVERY CHARACTERISTICS OF THE $\frac{1}{20}$-SCALE MODEL OF THE McDONNELL XF3H-1 AIRPLANE IN THE DESIGN GROSS WEIGHT LOADING

[Loading point 1 in table II and figure 6; cockpit closed; landing gear and flaps retracted; recovery by rapid full rudder reversal except as noted (recovery attempted from, and steady-spin data presented for, rudder full-with spins); spins to pilot's left]



[a]Model recovers in an inverted dive.
[b]Visual estimate.
[c]Recovery attempted before model reached final steep attitude.
[d]Model recovers in an erect glide.

Model values converted to corresponding full-scale values.
U inner wing up
D inner wing down

α (deg)	ϕ (deg)
V (fps)	Ω (rps)
Turns for recovery	

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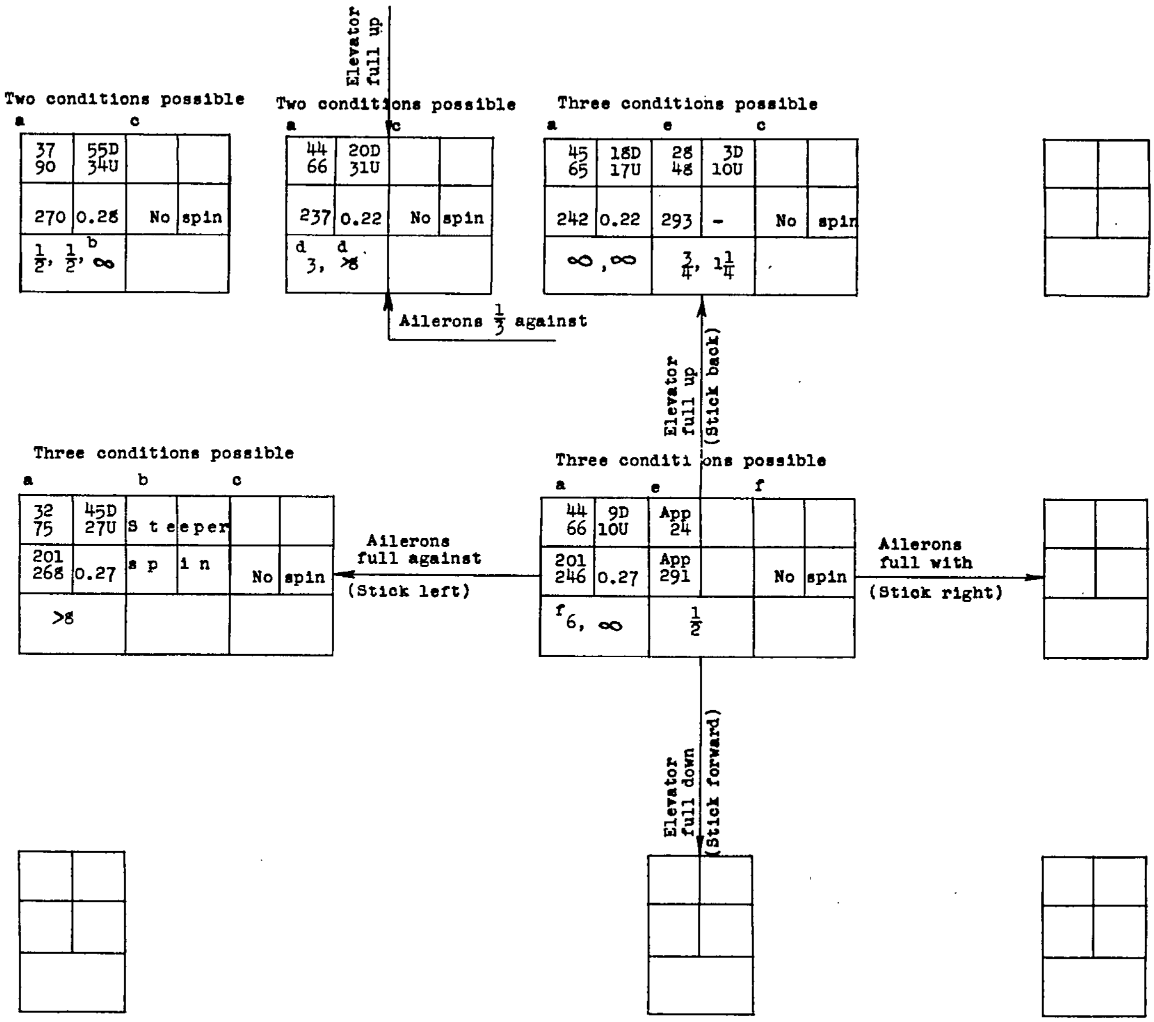
CHART 3.- SPIN AND RECOVERY CHARACTERISTICS OF THE $\frac{1}{20}$-SCALE MODEL OF THE McDONNELL XF3H-1 AIRPLANE WITH MASS EXTENDED ALONG THE FUSELAGE

[Loading point 4 in table II and figure 6; cockpit closed; landing gear and flaps retracted; recovery by rapid full rudder reversal except as noted (recovery attempted from, and steady-spin data presented for, rudder full-with spins); right erect spins]



[a] Oscillatory spin. Range of values or average value given.
[b] Visual observation.
[c] After launching, model motion became very oscillatory in roll, yaw, and pitch until the model abruptly dived out of the spin and started rolling left with the ailerons.
[d] Recovery attempted by reversing the rudder from full with to $\frac{2}{3}$ against the spin.
[e] Only sparse developed spin data available.
[f] Model recovered in an erect glide.

Model values converted to corresponding full-scale values.
U inner wing up
D inner wing down

α (deg)	φ (deg)
V (fps)	Ω (rps)
Turns for recovery	

NACA

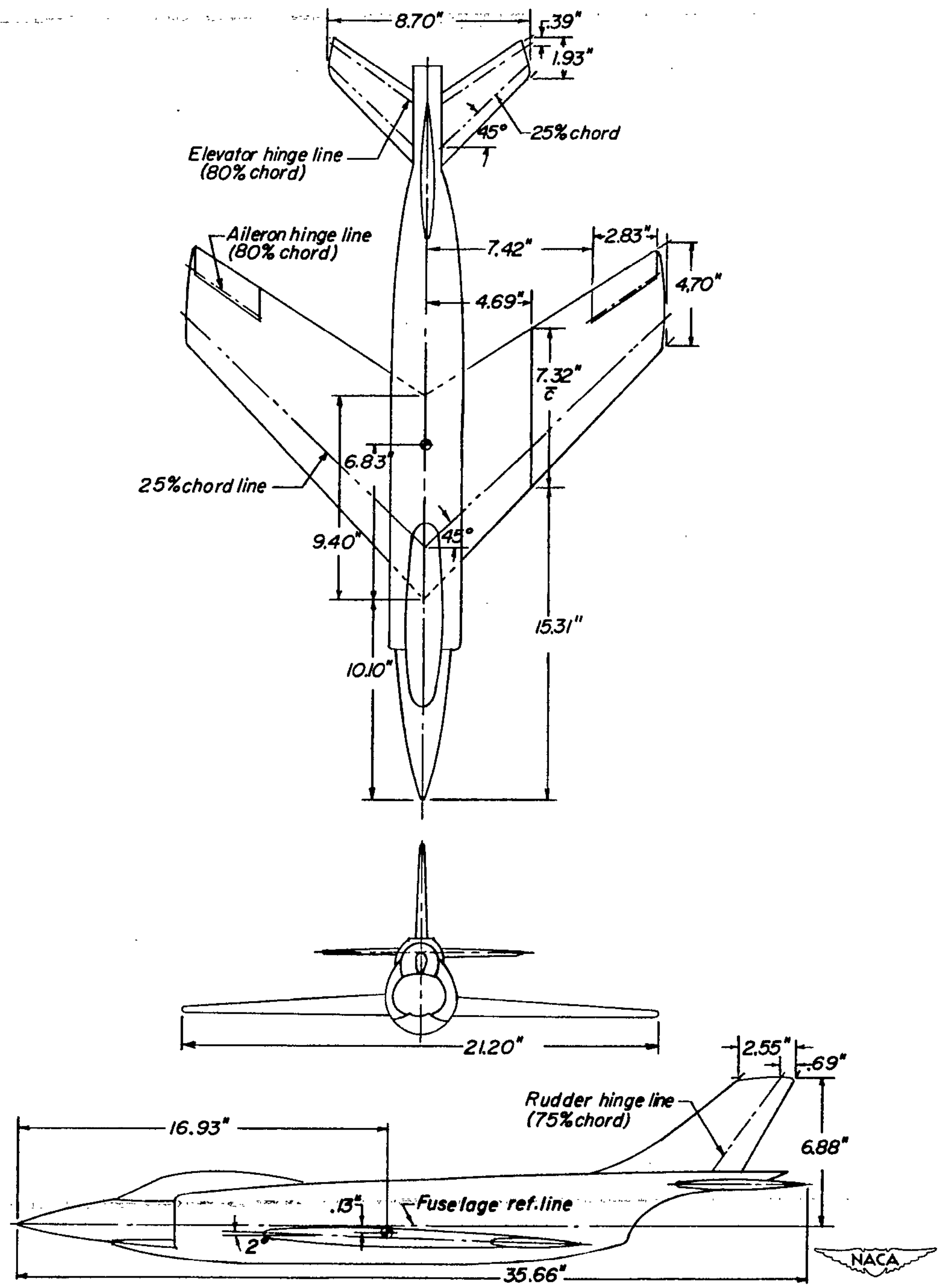


Figure 1.- Three-view drawing of the $\frac{1}{20}$ - scale model of the McDonnell XF3H-1 airplane. Center-of-gravity location is shown for the design gross-weight condition. (Stall-control vanes and wing-tip skids are omitted.)

[redacted]

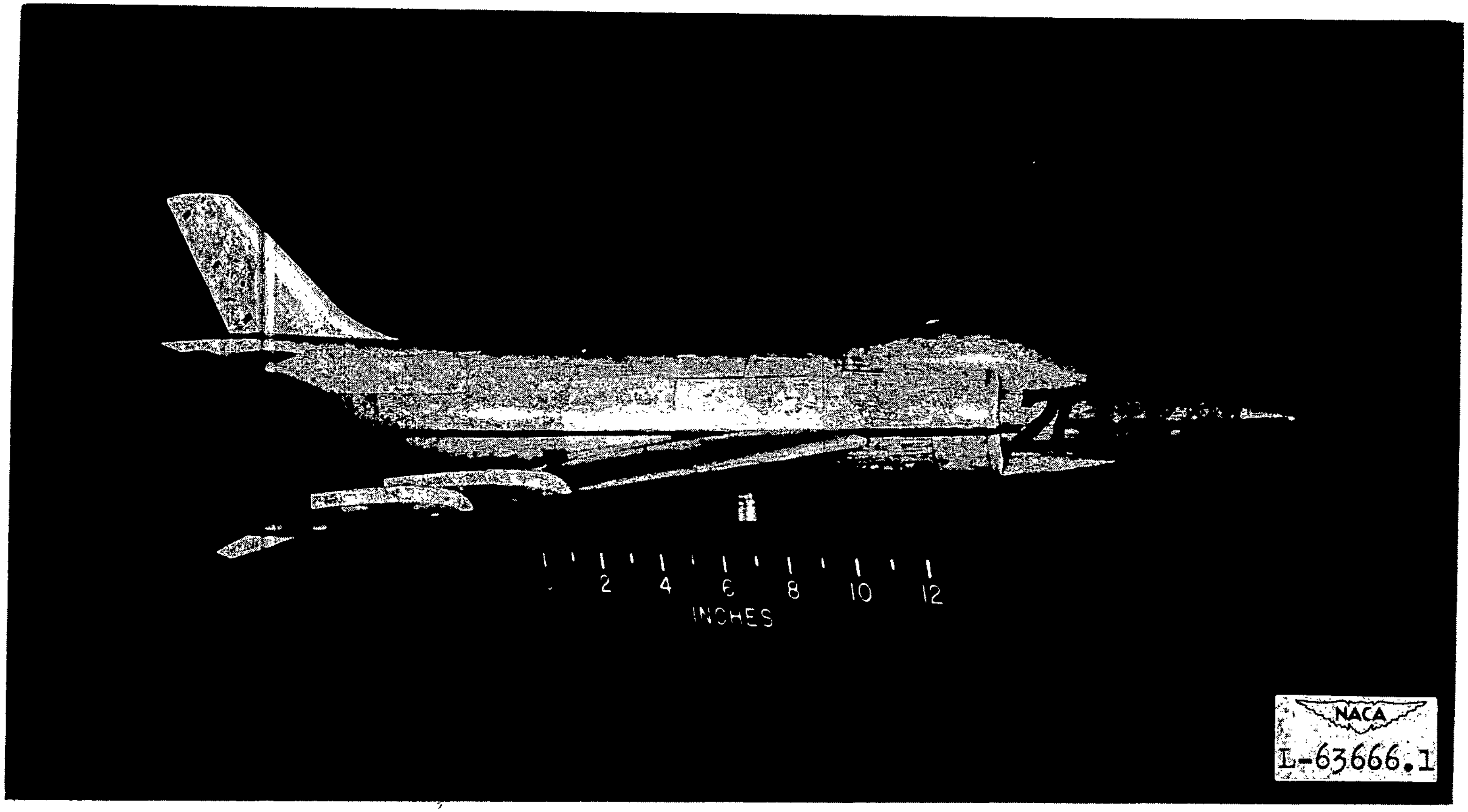


Figure 2.- The $\frac{1}{20}$ - scale model of the McDonnell XF3H-1 airplane in the normal flying condition.

[redacted]

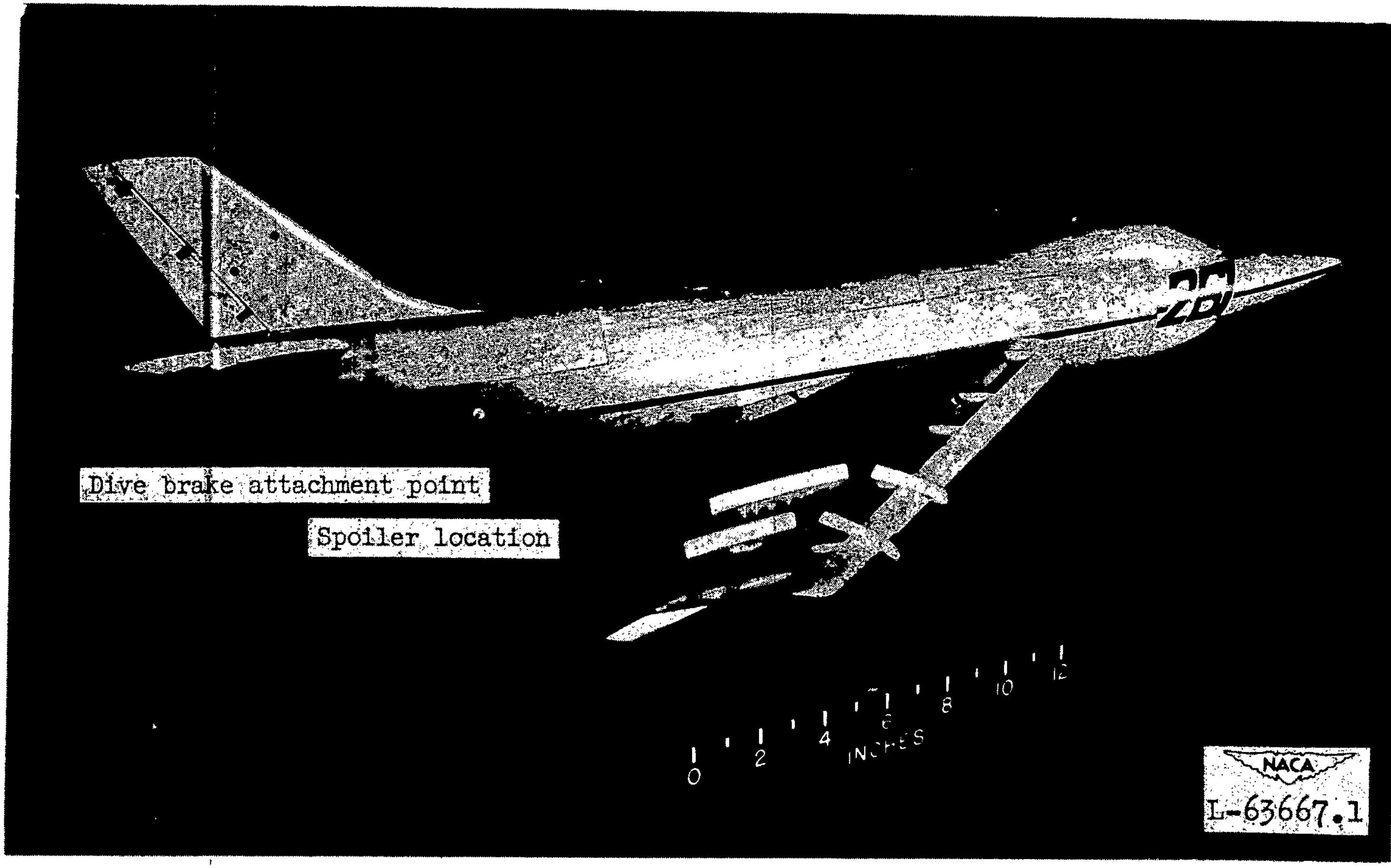


Figure 3.- The $\frac{1}{20}$-scale model of the McDonnell XF3H-1 airplane with the slats extended.

[redacted]

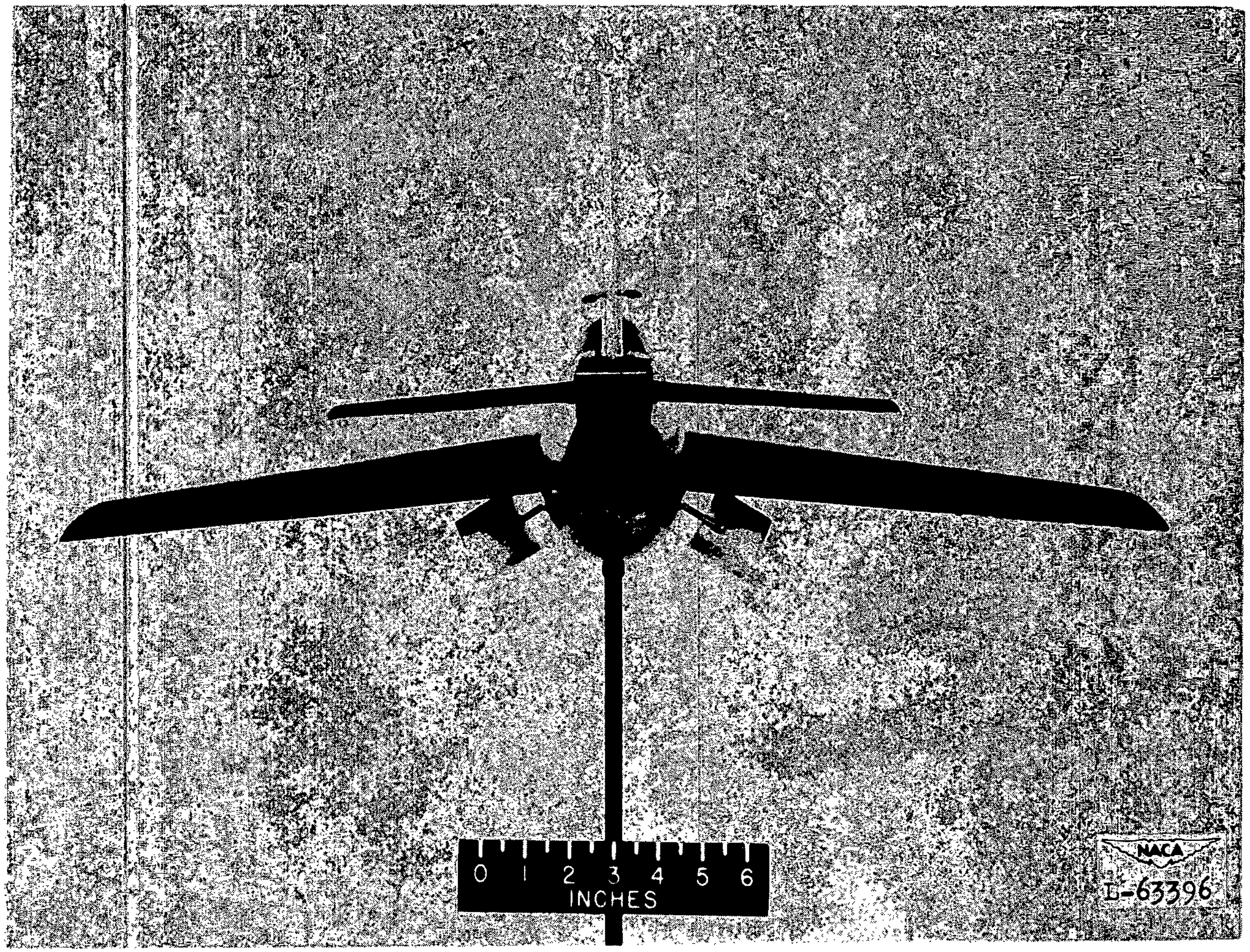


Figure 4.- The $\frac{1}{20}$-scale model of the McDonnell XF3H-1 airplane with the dive brakes extended. (Stall-control vanes and wing-tip skids are omitted from photograph.)

[redacted]

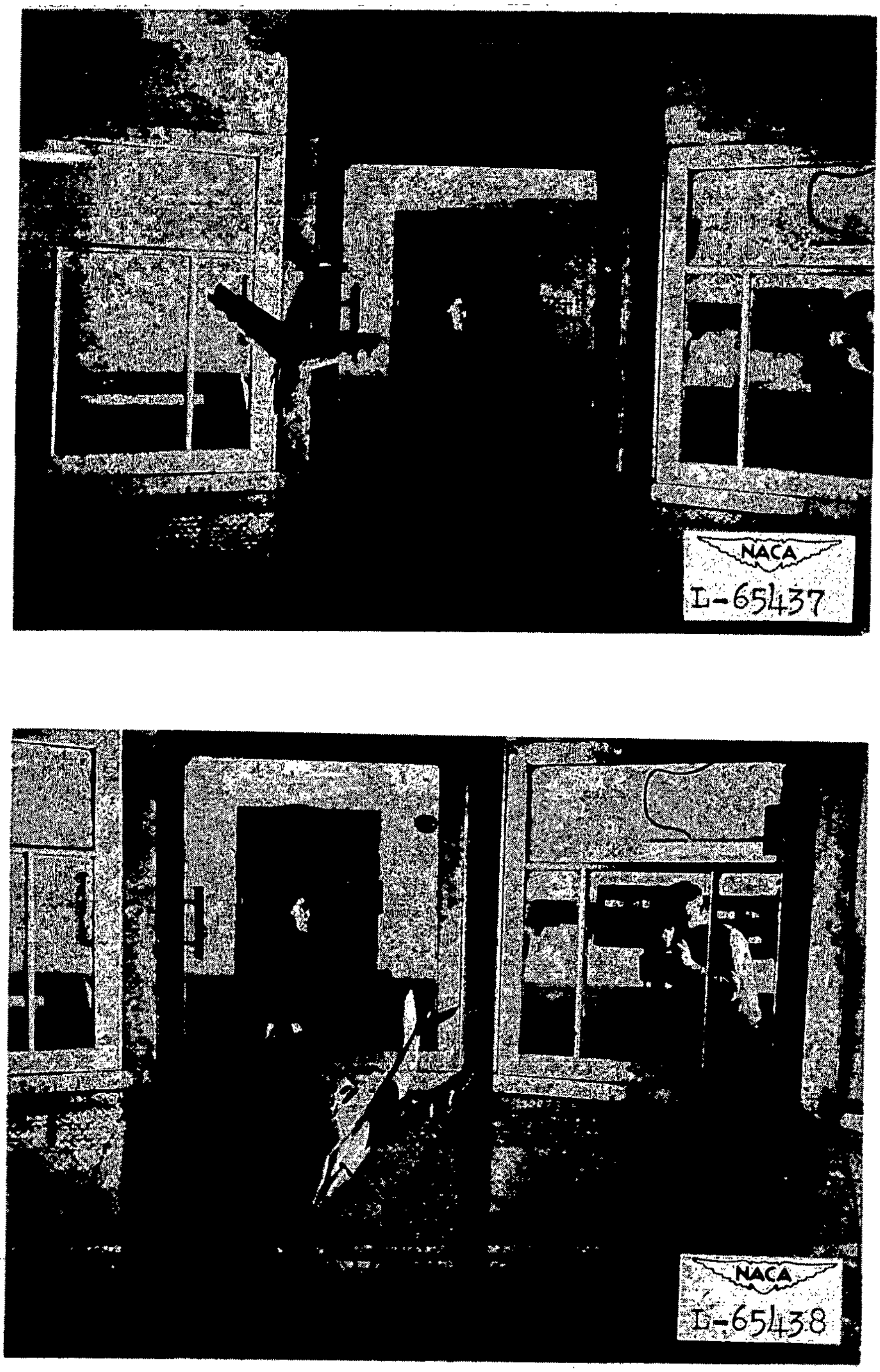


Figure 5.- The $\frac{1}{20}$-scale model of the McDonnell XF3H-1 spinning in the Langley 20-foot free-spinning tunnel.

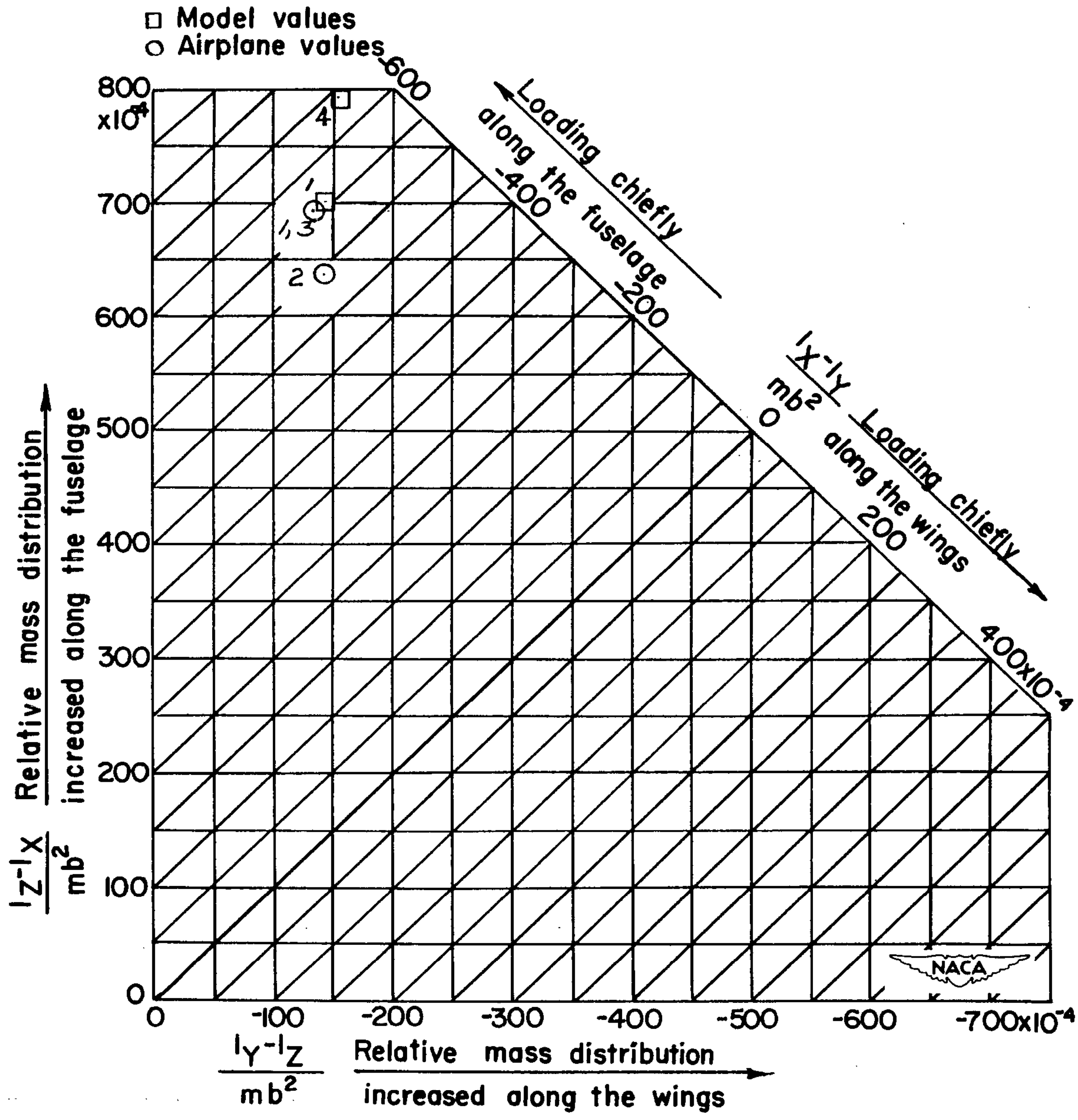


Figure 6.- Mass parameters for loadings possible on the McDonnell XF3H-1 airplane and for the loading tested on the model. (Numbers refer to the loadings listed in table II.)